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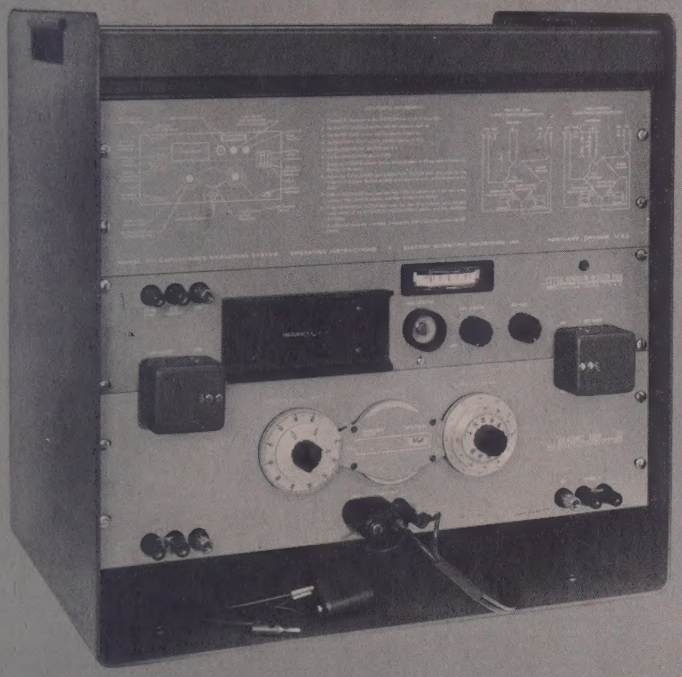
Electro Scientific Industries
7524 S. W. MACADAM AVE. • PORTLAND 19, OREGON

Catalog Sheet

BRIDGES AND ACCESSORIES

C-15

DECEMBER 1962
REPLACES MARCH 1962



CAPACITANCE MEASURING SYSTEM

MODEL 271

Wide Range Measurements with 0.1% Accuracy

The ESI Model 271 Capacitance Measuring System consists of the ESI Model 277 Capacitance Bridge and the ESI Model 860A AC Generator-Detector mounted in a custom metal cabinet. The system has a wide range measurement capability using the precision bridge, matched generator and sensitive detector. Shielded test leads and front panel operating instructions simplify accurate measurements. Extended capacitance and dissipation factor range is available in the ESI Model 271H Capacitance Measuring System which features the ESI Model 277H Capacitance Bridge.

The Model 277 Capacitance Bridge measures two and three-terminal capacitors to 120 μf with a resolution of 0.01 picofarads on the lowest range. The Model 277H will measure to 1200 microfarads with a resolution of 0.1 picofarads on the lowest range. The unknown capacitor is measured in terms of the capacitance and dissipation factor of its equivalent series circuit. Stray capacitance in parallel with the unknown is eliminated by internal bridge shielding and by the use of shielded leads. Capacitance value and dissipation factor are presented as coaxial dial in-line readouts for fast, error-free measurements.

The Model 860A AC Generator-Detector consists of a voltage source and sensitive tuned detector designed to optimize bridge performance. The generator provides up to 15 volts output and is power limited to 0.1 watt for circuit protection. The detector is tuned to the generator frequency to minimize harmonic response and hum pickup. The panel-mounted meter gives easily observed null variations and the electron ray null indicator give instantaneous response to signal changes for rapid, precision bridge balancing. Detector output and synchronization terminals are available for connecting an external null indicator.

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Specifications

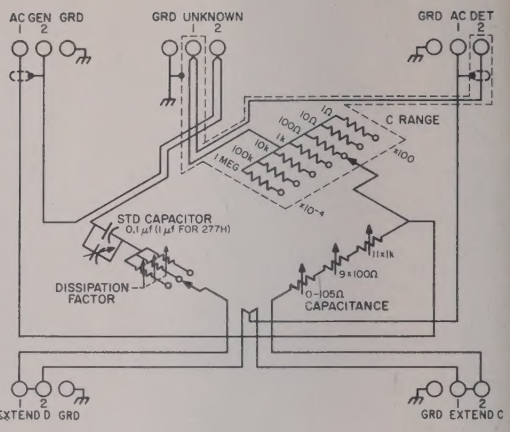
MODEL 277

Capacitance Readings

Number of Ranges:	Seven.
Dial Resolution:	12,005 divisions full scale on any range.
Highest Range:	0 to 120 μf.
Lowest Range:	0 to 120 pf; 1 dial division represents 0.01 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

Dissipation Factor Readings

Number of Ranges:	Three.
Dial Resolution:	105 divisions full scale on any range.
Highest Range:	0 to 1.05 x frequency in kilocycles.
Lowest Range:	0 to 0.0105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.0001.
Accuracy*:	±(2% + 0.0005).



MODEL 277H

Capacitance Readings

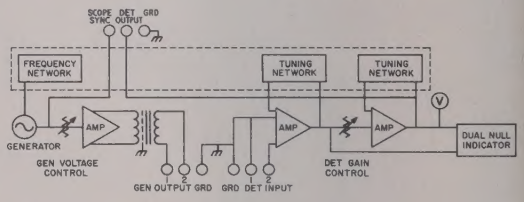
Highest Range:	0 to 1200 μf.
Lowest Range:	0 to 1200 pf; 1 dial division represents 0.1 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

Dissipation Factor Readings

Highest Range:	0 to 10.5 x frequency in kilocycles.
Lowest Range:	0 to 0.105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.001.
Accuracy*:	±(2% + 0.0005).

MODEL 860A

Generator Voltage:	0 to approximately 15 volts. Internal resistance is approximately 600 ohms. Generator output terminals are insulated from ground and have capacitance to ground of less than 30 pf.
Generator Frequency:	1 kilocycle network, accurate to ± 1% supplied. 0.1, 0.4 and 10 kilocycle units available. Units between 0.05 and 10 kilocycles made to order.
Detector Indicator:	Meter plus electron ray null indicator with instantaneous response to signal changes. Dual display for strong and weak signal changes.
Detector Sensitivity:	At maximum gain, meter and lower half of eye respond to signals, approximately 20 microvolts to 0.01 volts. Upper eye between 0.01 volts and 5 volts.
Detector Selectivity:	Network tuned to generator frequency. Second harmonic response down at least 30 db.
Power Supply:	115 volts, 50/400 cycles. 230 volt transformer available.

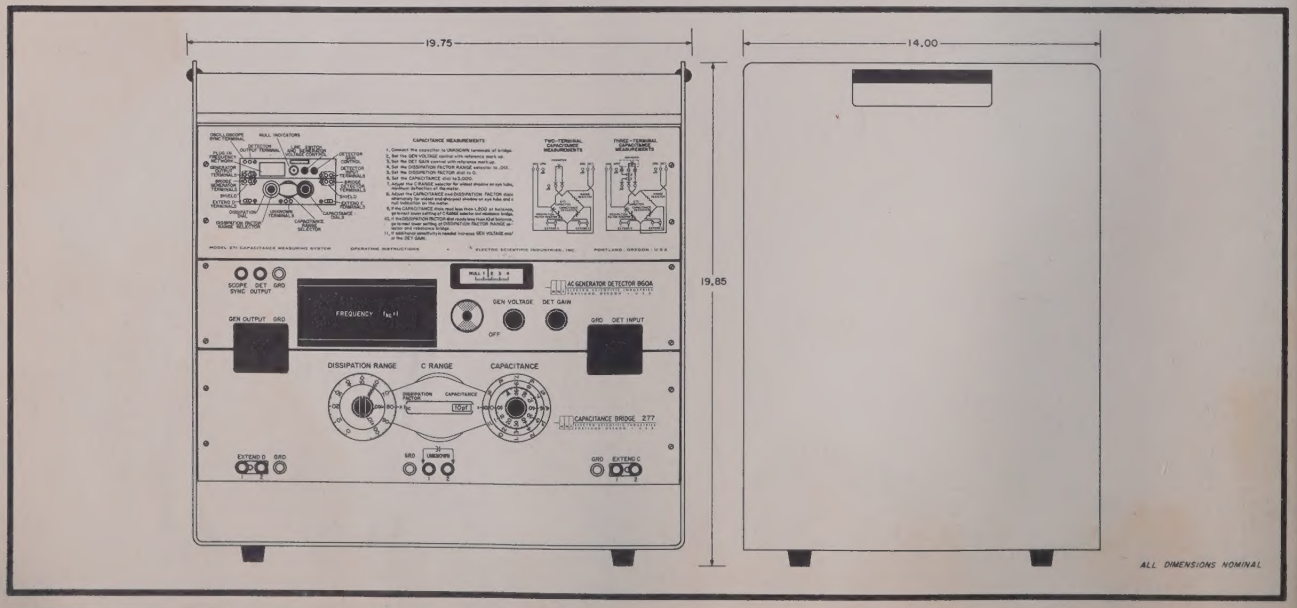


PHYSICAL SPECIFICATIONS

MODEL 271 and 271H	DIMENSION 19.75 W x 19.85 H x 14 D	NET WEIGHT 50 lbs	PRICE $ 650.00
277 and 277H	19 W x 7 H x 7 D	18 lbs	310.00
860A	19 W x 3 1/2 H x 8 D	10 lbs	280.00

PART NO. 1560 Shielded lead set (included with Model 271 and Model 271H) 12.00

*NOTE: Accuracy ratings apply at a frequency of 1 kc and at a temperature of 25°C. Slightly larger errors may be encountered at frequency or temperature extremes. Capacitance accuracy specifications apply when the bridge has been recently standardized against a reference standard capacitor. The long-term drift in calibration will not exceed 0.1% per year (Model 277), 0.2% (Model 277H) and any such drift can be corrected by a single adjustment to restandardize the bridge against any certified reference standard capacitor.



Electro Scientific Industries

7524 S. W. Macadam Avenue, Portland 19, Oregon

(formerly Electro-Measurements)

JUL 24 1963

INSTRUCTION MANUAL

ESI Model 271

CAPACITANCE MEASURING SYSTEM

BRIDGE PORTION
271

ELECTRO SCIENTIFIC INDUSTRIES
7524 S. W. Macadam Ave.
Portland 19, Oregon

November, 1962

PRICE 6½

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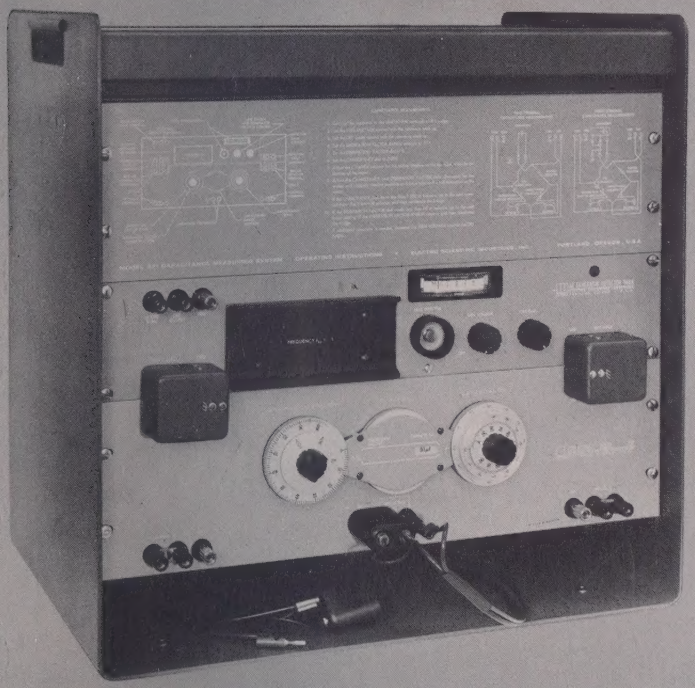

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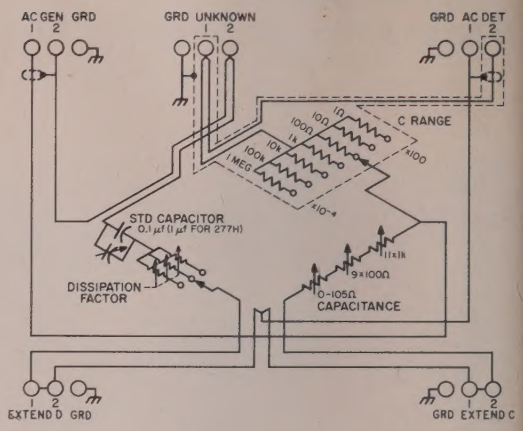

MODEL 277H

Capacitance Readings

Highest Range:	0 to 1200 μf.
Lowest Range:	0 to 1200 pf; 1 dial division represents 0.1 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

Dissipation Factor Readings

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Detector Sensitivity:	At maximum gain, meter and lower half of eye respond to signals, approximately 20 microvolts to 0.01 volts. Upper eye between 0.01 volts and 5 volts.
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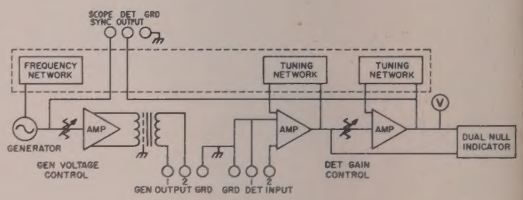

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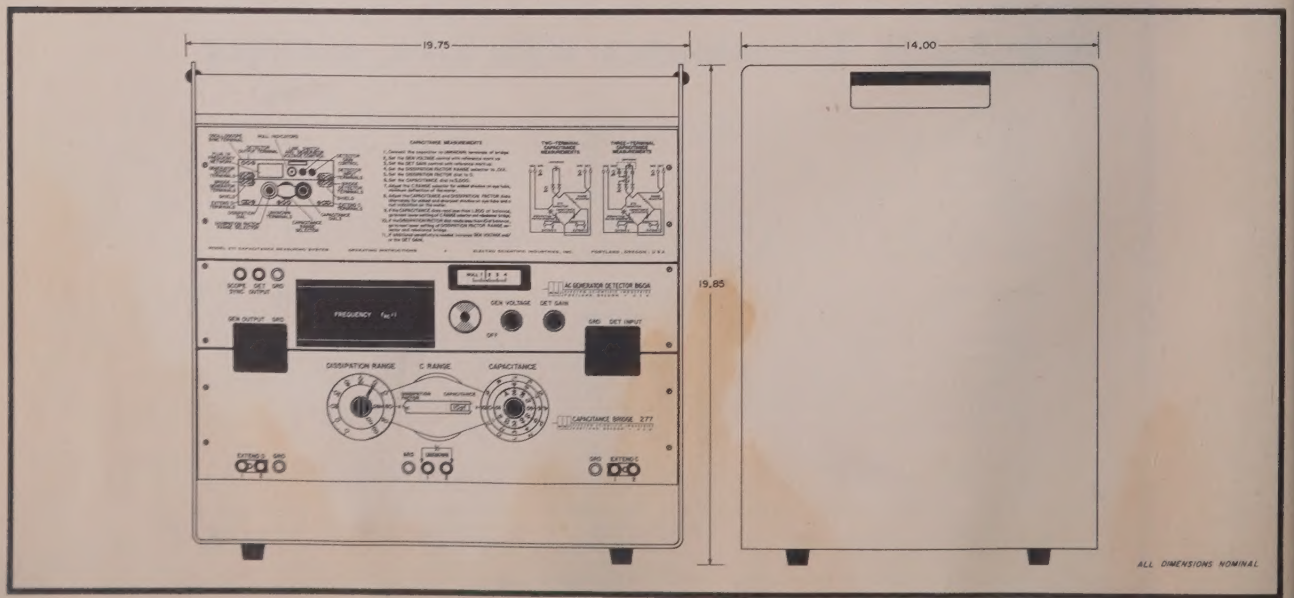

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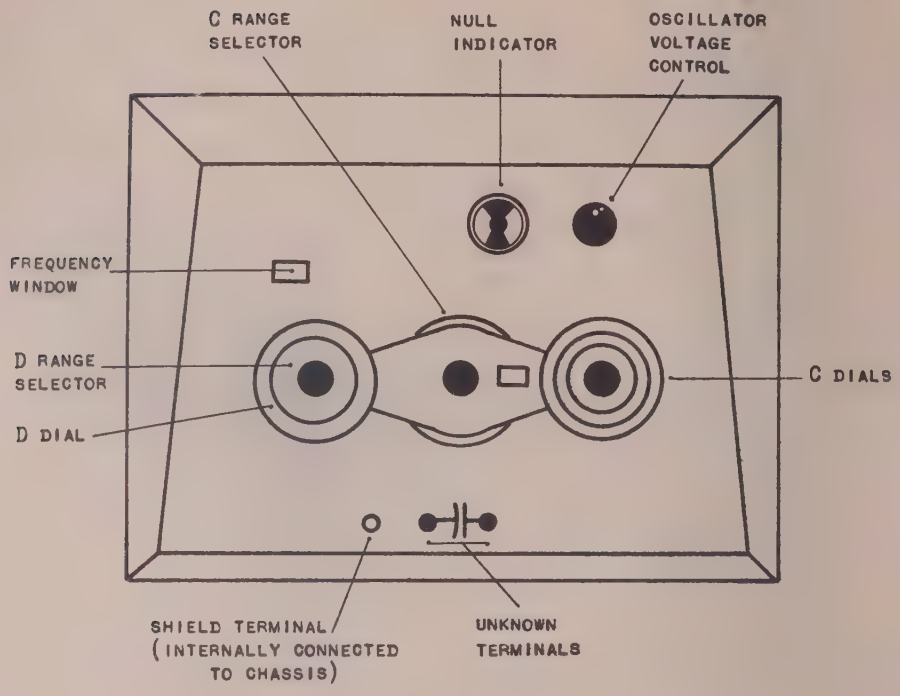
1. INTRODUCTION

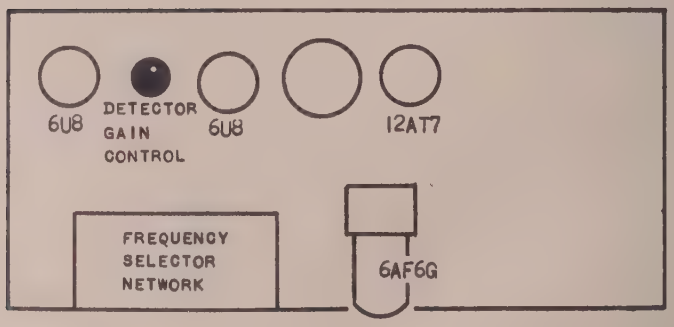
The ESI type 270 CAPACITANCE BRIDGE is a portable, self-contained instrument for the rapid and accurate measurement of capacitance. Values of equivalent series capacitance and dissipation factor can be read directly from the dial settings.

The unit consists of an accurate, well-shielded capacitance bridge, including associated generator, detector, and indicator. The case and controls have been human-engineered for maximum accuracy and operator convenience. All the necessary controls are located and clearly identified on the front panel. The adjustable legs permit tilting the instrument to any convenient angle, and can also be positioned to provide a carrying handle.

MODEL 270 PANEL ARRANGEMENT



TOP VIEW OF 270 CHASSIS (COVER RAISED)



2.2. CONTROLS

2.2.1. Frequency Selecting Network

The plug-in unit determines the operating frequency of both the generator and detector.

2.2.2. Dissipation Factor Range Selector

The inner left-hand dial selects from three dissipation factor ranges.

2.2.3. Dissipation Factor (D dial)

The outer left-hand dial indicates the magnitude of the dissipation factor when its indicated value is multiplied by the dissipation factor range selector setting and the frequency in kilocycles.

2.2.4. Capacitance Range Selector

The center dial selects from seven available capacitance ranges.

2.2.5. Capacitance Value Dials (C dials)

The reading of the three dials on the right, multiplied by the capacitance range setting, is the value of the capacitance of the unit connected to the unknown terminals.

2.2.6. Null Indicator

The dual electron ray null indicator provides an extremely broad range of sensitivity. The upper eye responds to large signals and the lower eye responds to very weak signals. A null is indicated by the maximum opening of both eyes.

2.2.7. Unknown Terminals

The unknown terminals have been located below the dials to provide maximum lead accessibility and easy use of the dials without excessive hand capacitance.

2.2.8. Oscillator Voltage Control

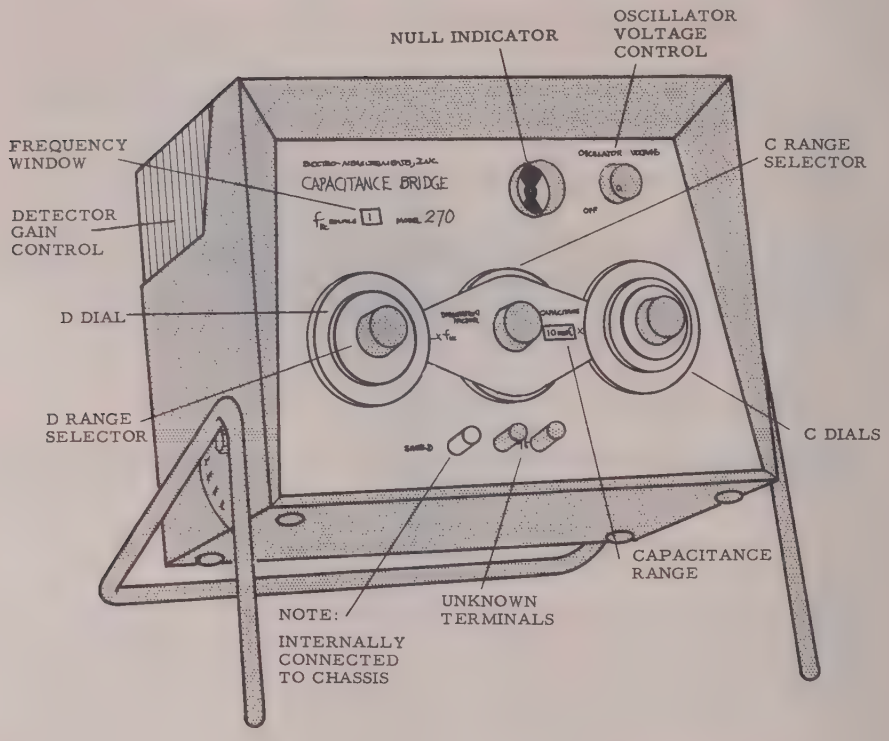
This knob controls the output voltage of the oscillator and operates the external power switch

2.2.9. Detector Gain Control

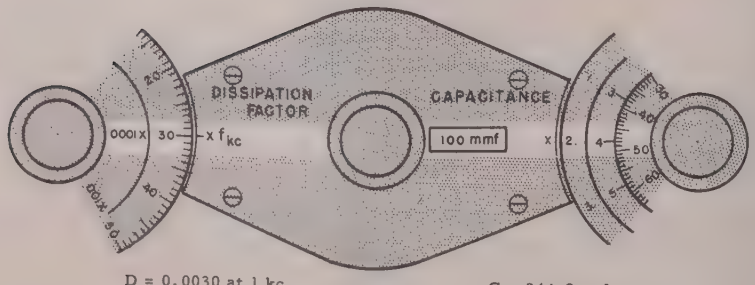
For added flexibility, there is a knob inside the case to adjust the detector gain. Clockwise rotation increases the gain. Where hum pickup is unavoidable, often measurements can be made more easily by reducing the detector gain and increasing the oscillator voltage

The detector gain control affects only the more sensitive lower half of the eye.

MODEL 270 CAPACITANCE BRIDGE



"IN LINE" READ-OUT



2.3

MEASURING CAPACITANCE

the esi way

2.3.1. Basic Instructions

Connect the capacitor to the UNKNOWN TERMINALS (marked).

Set the OSCILLATOR VOLTAGE control with the dot up.

Set the DETECTOR GAIN CONTROL to maximum. (This control is inside the case and is ordinarily left at maximum.)

Set the D RANGE SELECTOR at .01X.

Set the D DIAL at 0.

Set the C DIALS to read 3.000.

Adjust the C RANGE SELECTOR for maximum opening of the null indicator.

Adjust the C DIALS and the D DIAL alternately for maximum opening of the null indicator.

If additional sensitivity is needed, turn the OSCILLATOR VOLTAGE CONTROL clockwise.

If the C dial reading is less than 1.200, go to the next lower setting of the C range selector.

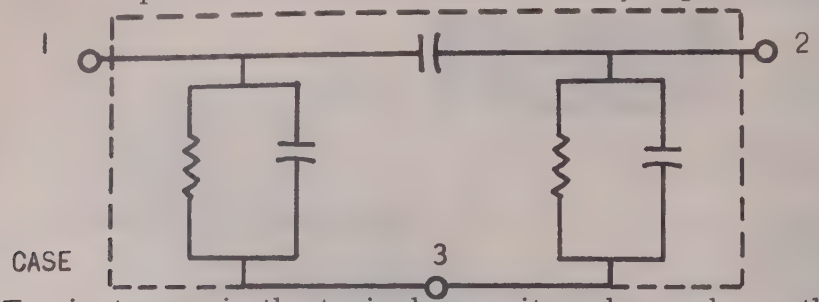
If the D dial reading is less than 10, go to the next lower setting of the D range selector.

The values of series capacitance C and dissipation factor D are as follows:

C = (C range selector setting) x (C dial reading)
D = (D range selector setting) x (D dial reading) x (f_{kc})

2.3.2. Three-Terminal Capacitors

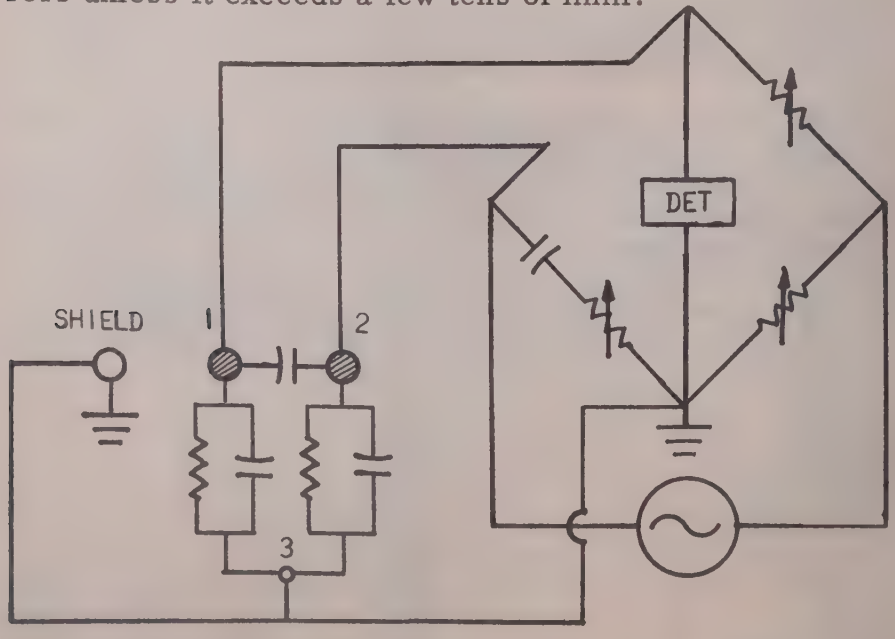
Three-terminal measurements make it possible to measure direct capacitance accurately by isolating the unknown capacitor from the effects of stray capacitances.



For instance, in the typical capacitor shown above, there is stray capacitance from each plate to the case and leakage resistance. With two-terminal techniques, this causes an error in measurement. The bridge reading does not give the capacitance between the plates, but the total impedance of the entire network as seen from terminals 1 and 2

To isolate the direct capacitance, the capacitor case is used as a third terminal and is connected to the shield terminal of the bridge. If one of the stray capacitances is known to be greater, it should be connected from the center terminal to the shield terminal of the bridge. Thus this stray capacitance appears across the detector where it will cause no error. However, large values may reduce the detector sensitivity.

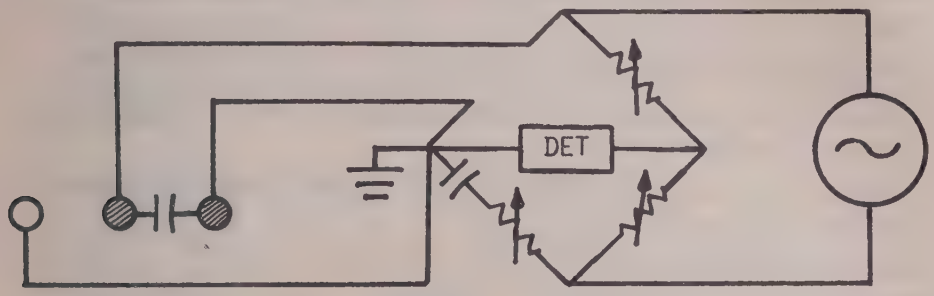
The other stray capacitance is then across the standard capacitor arm of the bridge, in parallel with the standard capacitor. As the standard capacitor is 100,000 mmf, the stray capacitance will not cause significant errors unless it exceeds a few tens of mmf.



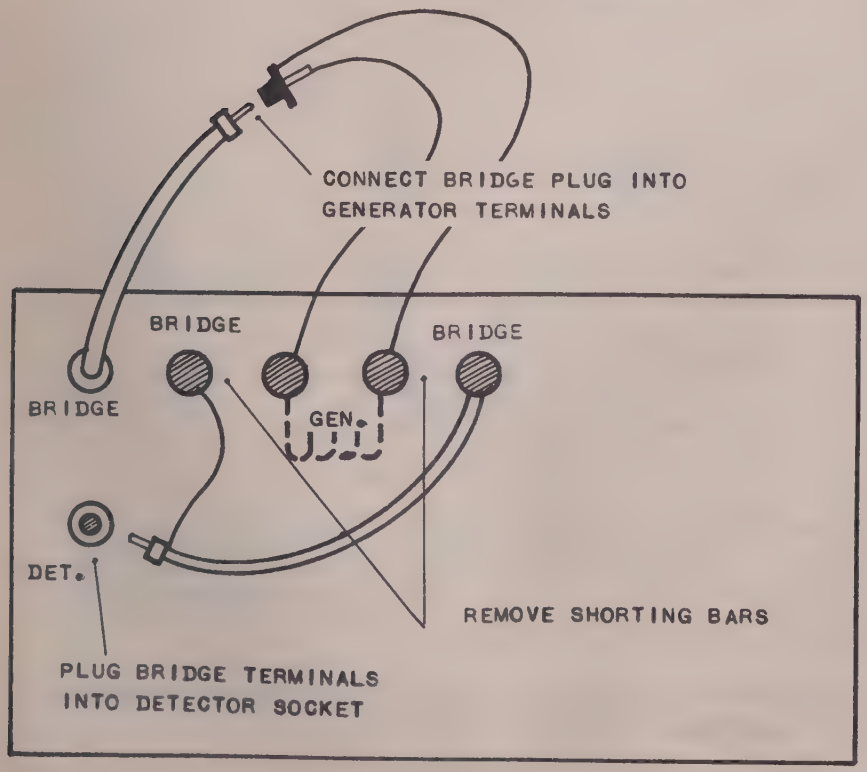
2.3.3. Grounded Capacitance Measurements

Because of inherent errors in making grounded capacitance measurements, the Model 270 Capacitance Bridge has been designed for ungrounded operation. For a grounded measurement several precautions and bridge changes are necessary. In making a grounded measurement the accuracy of the measurement may be reduced.

The generator and detector corners of the bridge must be interchanged. This is done be making the connections shown in the sketches below:



Bridge connections for grounded measurements



Circuit change for grounded measurements
(Top view of bridge with cover raised)

This connection throws nearly 100 mmf of internal capacitance across the unknown terminals of the bridge, so that a zero capacitance measurement is necessary. No appreciable correction will be needed for large capacitances.

2.3.3.1. Procedure:

Make the necessary changes in the bridge circuit.

With nothing connected to the terminals, balance the bridge.

Record these values as C_o and D_o.

Connect the ground side of the capacitor to the right-hand terminal of the bridge.

Connect the other terminal of the capacitor to the center terminal of the bridge.

Balance the bridge.

Record these values as C_m and D_m.

Compute the values of the unknown capacitor, C_x and D_x from the following equations:

For approximate values--

$$C_x = C_m - C_o$$

$$D_x = \frac{C_m D_m - C_o D_o}{C_x}$$

For maximum accuracy--

$$D_x = \frac{C_m D_m (D_o^2 + 1) - C_o D_o (D_m^2 + 1)}{C_m (D_o^2 + 1) - C_o (D_m^2 + 1)}$$

$$C_x = (D_x^2 + 1)\left(\frac{C_m}{D_m^2 + 1} - \frac{C_o}{D_o^2 + 1}\right)$$

2.3.3.2. Expected accuracy:

With grounded connections, the accuracy after calculation is approximately as follows:

$\pm$(1% + 1 mmf) for capacitance

$\pm$(.001 + 5% of reading) for dissipation factor

2.4. THINGS TO WATCH OUT FOR

2.4.1. Low Capacitance Measurements

In making low capacitance measurements, there are two things to watch out for:

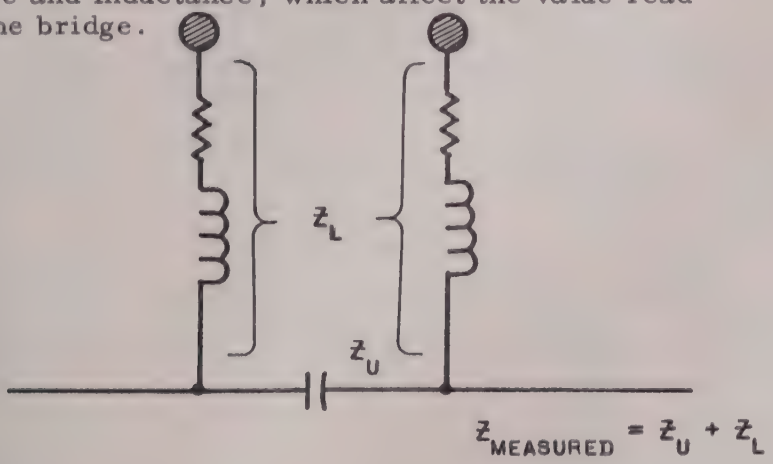
Be careful to avoid hum pickup.
Keep the stray capacitance at a minimum.

To minimize both effects, keep your hands as far as possible from the capacitor being measured.

Keep the leads as short and direct as possible. If extended leads are necessary, the lead from the center terminal should be shielded. See section 2.9., "Extended Leads."

2.4.2. High Capacitance Measurements

The bridge measures the total impedance connected to its terminals. Both the unknown capacitor and its leads contribute to this impedance. The leads have some resistance and inductance, which affect the value read from the bridge.



$\bar{Z}_U$ = Impedance of unknown capacitor

$\bar{Z}_L$ = Impedance of leads

For the greatest accuracy, minimize the lead impedance. Short heavy leads will reduce the resistance. Closely-spaced twisted leads will reduce the inductance and the pickup of stray fields.

2.5. POLARIZING VOLTAGE

2.5.1. When to use a Polarizing Voltage

Some capacitors need a polarizing voltage. For example, electrolytic and tantalytic units can be damaged by the reverse polarity half-cycle of the test frequency. Even if the capacitors are not damaged, erroneous readings may result.

2.5.2. When a Polarizing Voltage is Not Necessary

A polarizing voltage is not always needed in these measurements. If the ac voltage is kept at a very low value, the capacitor will not be damaged, and the readings will be reasonably accurate.

Because of the high sensitivity of the Model 270 bridge, accurate measurements can be made with a very low oscillator voltage. When operating with a low oscillator voltage, be sure that the detector sensitivity is maximum.

2.5.3. How to Supply a Polarizing Voltage

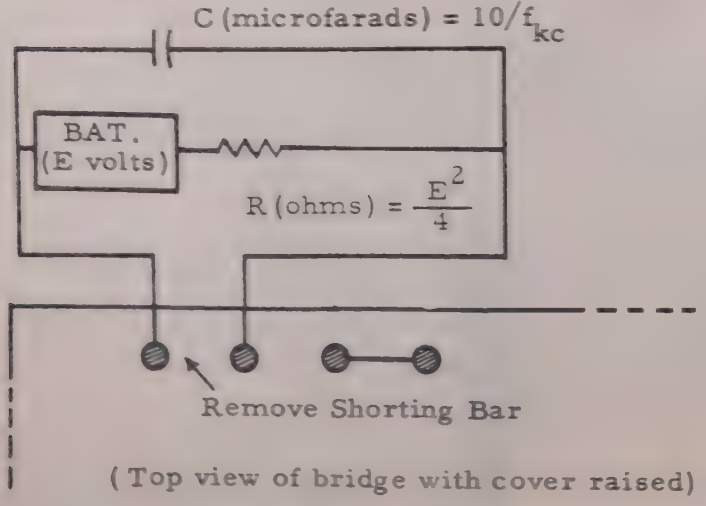
Terminals are provided on each side of the generator transformer for the insertion of a polarizing voltage.

Keep the dc source well insulated, and keep the capacitance to ground as small as possible. Use of a battery is recommended.

The maximum recommended polarizing voltage is 300 v.

The polarizing voltage should be in series with the ac generator. Direct current is then blocked from flowing through the bridge by the unknown capacitor in one arm, and the standard capacitor in the other arm.

The dc source should be by-passed by a capacitor. A current limiting resistor will protect the bridge from damage in case of short circuits.



(Top view of bridge with cover raised)

2.6. VOLTAGE MEASUREMENT

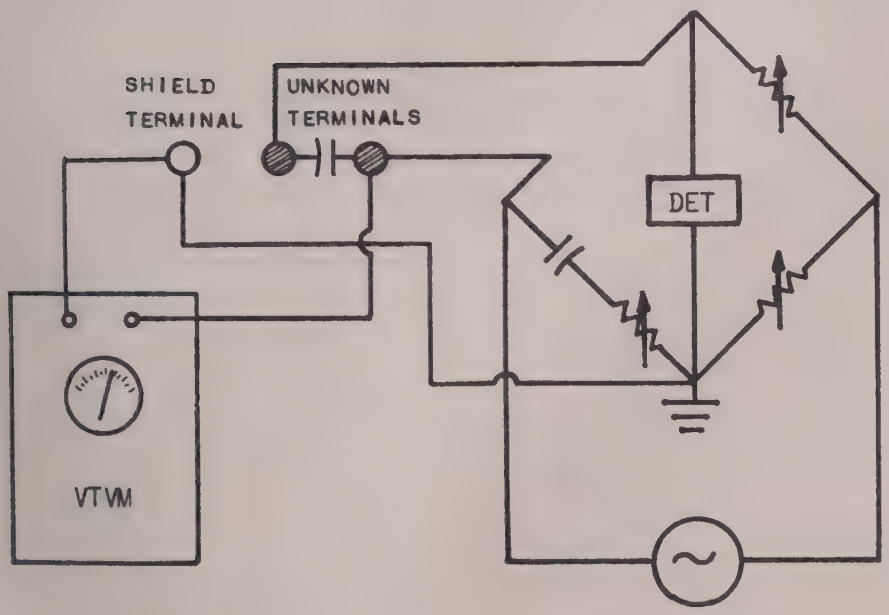
To measure the ac voltage applied across the unknown capacitor:

Connect the ground terminal of a high impedance ac voltmeter to the shield terminal of the bridge.

Connect the input terminal of the voltmeter to the right-hand terminal of the bridge.

Balance the bridge.

Read the voltmeter. With the bridge balanced, this voltage is equal to the ac voltage across the unknown capacitor, but the capacitor has not been loaded by the voltmeter. The bridge readings, however, may be incorrect while the meter is connected.



2.7. EQUIVALENT SERIES RESISTANCE AND STORAGE FACTOR

The bridge measures effective series capacitance and dissipation factor. From these values, storage factor and equivalent series resistance can be calculated.

$$Q = \frac{1}{D}$$

$$R_s = \frac{D}{2\pi f C_s}$$

Q = Storage factor

R_s = Equivalent series resistance, in kilohms

D = Measured dissipation factor

C_s = Measured equivalent series capacitance, in mf

f = Frequency, in kilocycles

2.8. EQUIVALENT PARALLEL CIRCUIT

From the equivalent series capacitance and dissipation factor measured, the equivalent parallel circuit can be derived.

$$Q = \frac{1}{D}$$

$$C_p = \frac{C_s}{1 + D^2}$$

$$R_p = \frac{1 + D^2}{D^2} R_s = \frac{1 + D^2}{D} \frac{1}{2\pi f C_s}$$

Q = Storage factor

C_p = Equivalent parallel capacitance, in mf

R_p = Equivalent parallel resistance, in kilohms

D = Measured dissipation factor

C_s = Measured equivalent series capacitance, in mf

R_s = Equivalent series resistance, in kilohms

f = Frequency, in kilocycles

The D of the equivalent parallel circuit always equals the D of the equivalent series circuit. The same is true of Q.

2.9. EXTENDED LEADS

Sometimes it is necessary to use extended leads. This can be done easily, without causing error in the measurement.

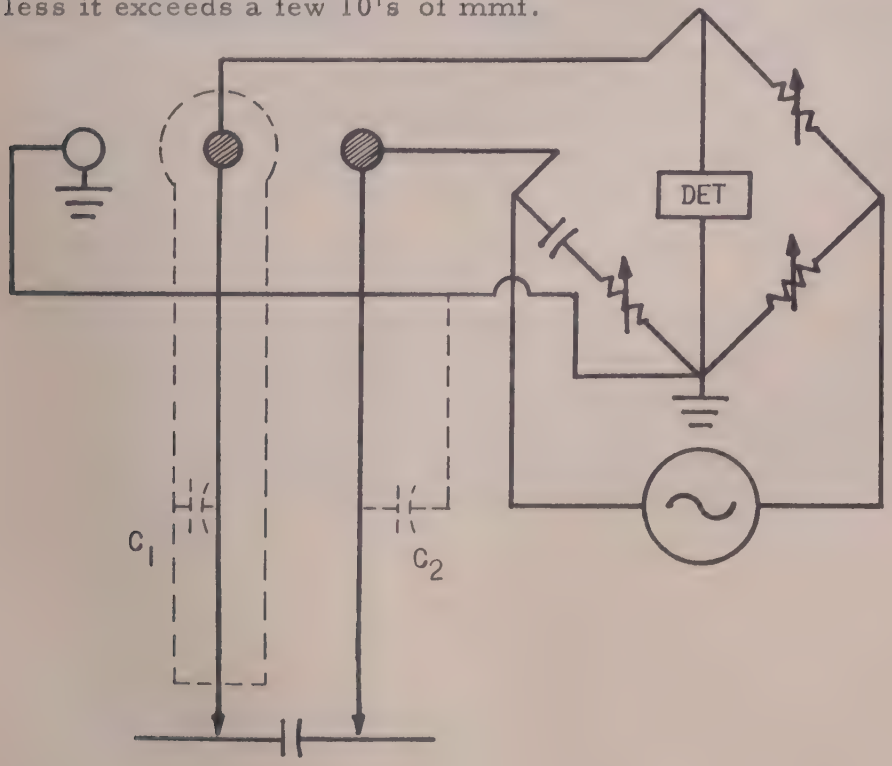
Connect a shielded lead to the center terminal.

Connect the shield of this lead to the shield terminal of the bridge.

Connect an ordinary clip lead to the right-hand terminal.

The capacitance between the shield and the center conductor is now across the detector. This keeps it from causing any error. If this stray capacitance is greater than 500 mmf, it may reduce the detector sensitivity.

The stray capacitance from the unshielded lead to ground is across the standard capacitance arm of the bridge. As the standard capacitor is 100,000 mmf, the stray capacitance will not cause significant errors unless it exceeds a few 10's of mmf.



C_1: Capacitance from center conductor to ground

C_2: Capacitance from unshielded conductor to ground

3. SPECIFICATIONS

Capacitance Range:

0 to 120 microfarads in 7 ranges

0.01 micromicrofarad per dial division on the lowest range

Accuracy: ±(0.20% + 1 dial division). Slightly larger errors may be encountered on the highest and lowest capacitance ranges.

Dissipation Factor Range at 1 kc:

0 to 1.05 in 3 ranges

0.0001 per dial division on lowest range

Accuracy: ±(0.0005 + 2% of the reading). Slightly larger errors may be encountered on the highest and lowest capacitance ranges.

4. MAINTENANCE

4.1 Cleaning of Slide-Wire Rheostat

Remove rear bridge cover.

Remove DEKASTAT dust cover. Follow instructions on dust cover.

Using a small strip of crocus cloth, wipe both slide wires. Make two or three continuous rotations. Care should be taken to rotate the slider out of the way to avoid changing its contact force. To complete cleaning, wipe slide-wires and contacts with a clean, dry, lint-free cloth to remove loose particles.

4.2. Adjusting Slide-Wire Rheostat

It is recommended that instrument be returned to factory if slide-wire contacts require adjustment. Where it is absolutely necessary to make repairs yourself, adjust each slider so that contact force measures 75 to 100 grams. USE EXTREME CAUTION to avoid damaging slide-wires.

GENERATOR DETECTOR COMPONENT PARTS

R-1	470K	10%	1/2W
R-2	10,000Ω	10%	1/2W
R-3	1.8 meg	10%	1/2W
R-4	180K	1%	1/2W
R-5	180K	1%	1/2W
R-6	47,000Ω	10%	1/2W
R-7	4,700Ω	10%	1/2W
R-8	10,000Ω	10%	1/2W
R-9	1.8 meg	10%	1/2W
R-10	180K	1%	1/2W
R-11	180K	1%	1/2W
R-12	2,700Ω	10%	1/2W
R-13	100K	10%	2W
R-14	47,000Ω	10%	1/2W
R-15	47,000Ω	10%	1/2W
R-16	22,000Ω	10%	1/2W
R-17	1,500Ω	10%	1/2W
R-18	22,000Ω	10%	1/2W
R-19	22,000Ω	10%	1W
R-20	100Ω	10%	1/2W
R-21	2.7 meg	10%	1/2W
R-22	180K	1%	1/2W
R-23	180K	1%	1/2W
R-24	820Ω	10%	1/2W
R-25	10 meg	10%	1/2W
R-26	470K	10%	1/2W
R-27	1.5 meg	10%	1/2W

F-1, F-2	1 amp	3 AG

SR-1, SR-2	20 ma, 320V	Selenium rectifier

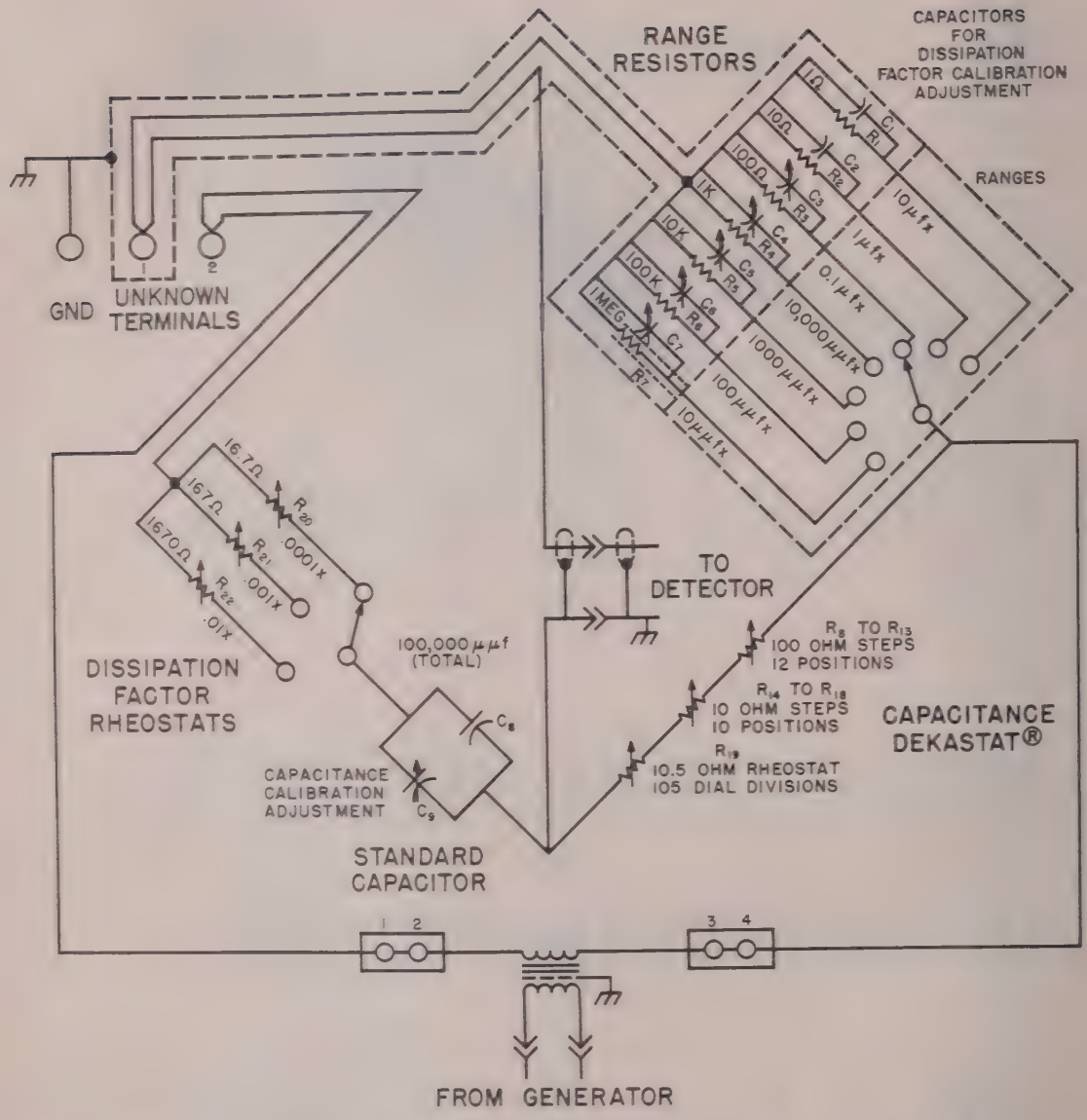
V-1	6U8A	
V-2	6U8A	
V-3	6AF6-G	
V-4	12AT7	

P-1	500K	10%	2W
P-2	500K	10%	2W

S-1	SPST	2A 125V

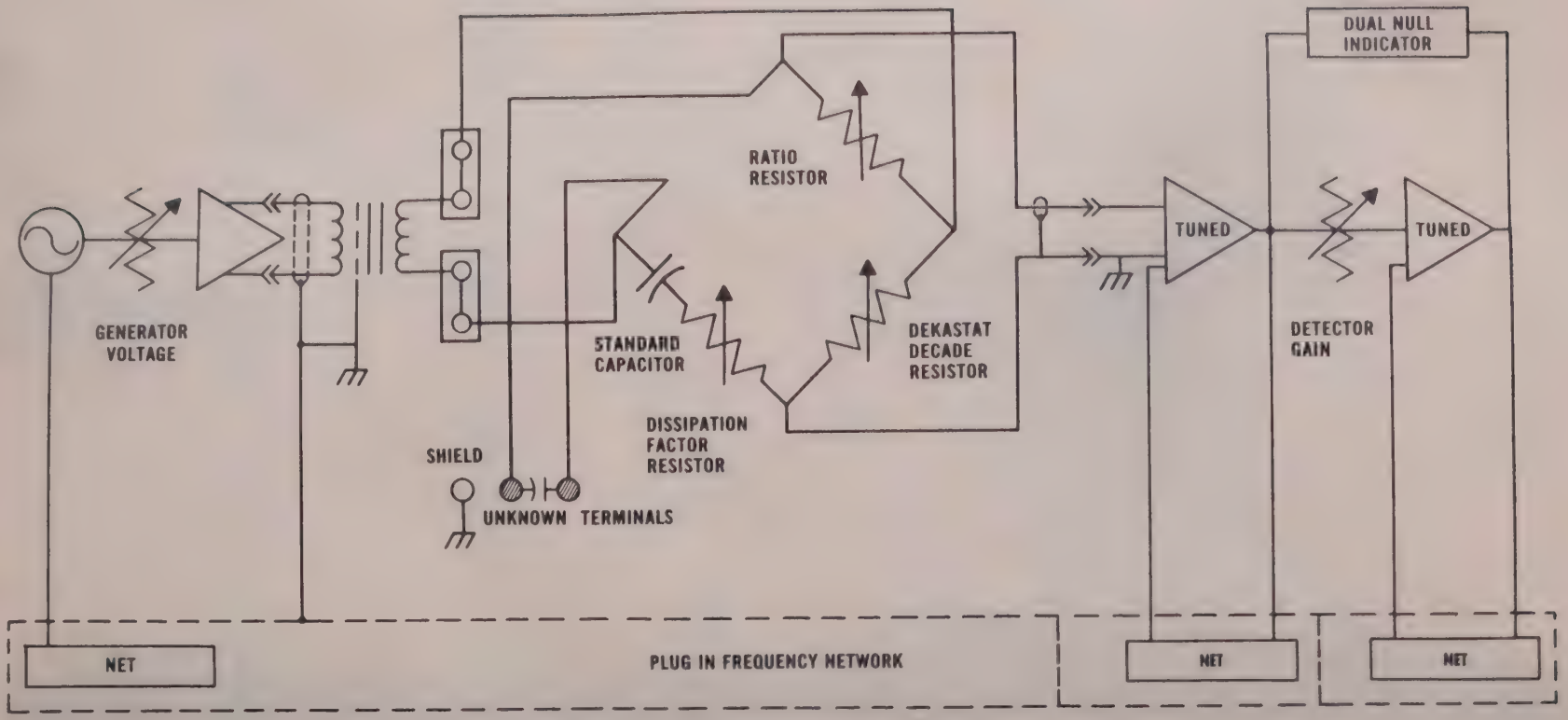
T-1	500VCT	20 ma. d.c.
	6.3VCT	2a.

C-1	0.01 µf	±20%	400V
C-2	25 µf		25V
C-3	0.01 µf	±20%	400V
C-4	15-15-15-15 µf		450V
C-5	15-15-15-15 µf		450V
C-6	15-15-15-15 µf		450V
C-7	15-15-15-15 µf		450V
C-8	25 µf		25V
C-9	0.1 µf	±20%	400V
C-10	0.01 µf	±20%	400V
C-11	0.01 µf	±20%	400V
C-12	0.01 µf	±20%	400V
C-13	33 µµf	5%	400V



5.1 MODEL 270 CAPACITANCE BRIDGE CIRCUIT DIAGRAM

GENERATOR • • • • • BRIDGE • • • • • DETECTOR



esi REV.A

270 11/57

MODEL 270 CAPACITANCE BRIDGE BLOCK DIAGRAM

CLAIM FOR DAMAGE IN SHIPMENT

This instrument should be tested upon receipt. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be forwarded to us by the claim agent. We will then advise you of the disposition to be made and arrange for repair or replacement. Include model and serial number when referring to this instrument.

WARRANTY

Electro Scientific Industries, Inc. warrants each instrument and component parts to be free from defects in material and workmanship. Electro Scientific Industries, Inc. will service any instrument and replace parts thereof (except tubes, fuses and batteries) which shall, within one year after making delivery to the original purchaser, prove to be unsatisfactory.

If the fault has been caused by misuse or abnormal conditions or operation, a nominal charge will be made for repairs. In this case, an estimate will be submitted before making such repairs.

Electro Scientific Industries, Inc. reserves the right to make changes in design at any time without incurring obligation to modify units previously purchased.

Electro Scientific Industries

7524 S. W. Macadam Avenue • Portland 19, Oregon

ESI instruments are carefully engineered and made to the most exacting standards of workmanship and accuracy in a modern and well-equipped factory.

Field Engineers are maintained in principal cities as a service to our customers. Customers are invited to contact our nearest field engineer or to consult our engineering staff for further information regarding ESI instruments and their applications.

esi®

Precision Products

Bridges and Accessories

Decade Voltage Dividers

Decade Resistors

Decade Capacitors

ESIAC Computers

Electro Scientific Industries

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esi **Precision** SYSTEMS FOR

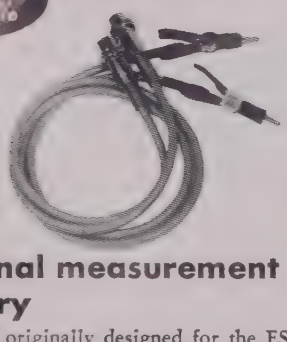
The Measurement System Concept

To attain the accuracy and precision of measurement demanded by moder science and technology requires much more than a precise and reliable measur ment instrument.

Accurate measurements also require a judicious combination of (1) basic mea urement techniques (2) the implementation of these techniques by carefull chosen instrumentation and (3) the availability of adequate reference standard to calibrate the instrumentation.

Intelligent selection of such parameters as impedance levels, operating voltage and frequencies, detector sensitivities and selectivity and connection methods ca insure maximum accuracy throughout a chain of measurements. Properly em ployed, this chain can be extended to provide direct traceability to referenc standards certifiable by the National Bureau of Standards. Specialized transfe standards can be used to simplify the chain and enhance both the accuracy an speed of measurements.

This is the measurement system concept—the integration of design, instrumen tation and "state-of-the-art" metrology techniques to provide incisive tools fo precise electrical measurements. These ESI measuring systems are specifically designed to meet the demanding requirements of this concept.



KELVIN KLIPS: 4 terminal measurement accessory

Kelvin Klips originally designed for the ESI Model 242 system—now available for making rapid, precision four-terminal resistance measurements even with relatively high lead and contact resistances. Kelvin Klips also provide a strong reliable low resistance, long life, all-purpose test clip for two-terminal applications. Price $7.50 for Klips only, or $25.00 assembled with shielded cable and spade lug terminations. Request Catalog Sheet C-31.

MODEL 242 RESISTANCE MEASURING SYSTEM

A precision resistance bridge of wide range, superior accuracy and extreme resolution Compares the percentage difference between the unknown resistance and the product o the standard resistance times the multiplier. Bridge multiplier accurate to better tha ±0.005%. Comparisons to an accuracy of 1 ppm are possible by using substitution tech niques. Measurements of ±0.01% accuracy can be made directly without calibratio and with no need for zero resistance or lead resistance correction. With a set of Mode SR-1010 Resistance Transfer Standards, measurements over a wide resistance range ar traceable to an NBS certified standard with an accuracy of a few ppm.

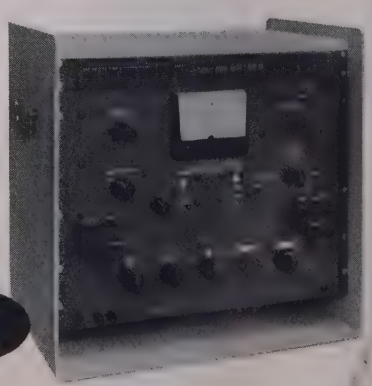
242—Resistance Measuring System—Ratio bridge, decade standard, and generator-detector in case with Kelvin Klips	$3,400.00
241—Resistance Comparison System—Ratio bridge and generator-detector in case	2,300.00
243—Ratio bridge and decade standard in case	2,200.00
240—Kelvin Ratio Bridge (Less Accessories)	900.00
800—DC Generator-Detector	1,300.00
RS-925—Decade Resistance Standard—0.01 ohm to 1.2 megohm, with 0.0001 ohm resolution in four-terminal connection	1,200.00
SR-1010—Resistance Transfer Standards (See separate description on Standards page)	each 250.00

Request Catalog Sheet C-27 and Design Ideas Volume 1, 2 and 3.

MODEL 231-A GUARDED WHEATSTONE RESISTANCE MEASURING SYSTEM

A precision, high resolution Wheatstone bridge. Five place readings; initial accuracy of ±0.005%, long term accuracy ±0.01%. Human engineered for simple operation and direct readout. Automatic decimal point location. Internal guarding permits accurate, high resolution measurements to 12 kilomegohms. Matching generator-detector provides 6 output ranges to match loads from 1 ohm to 100 kilohms. Mounted in attractive, rugged case.

231-A–Resistance Measuring Assembly (With Accessories)	$1,875.00*
230-A—Guarded Resistance Bridge (Less Accessories)	450.00*
800—Generator-Detector	1.300.00*



For Further Information Request Catalog Sheet C-21.

***All prices f.o.b. Portland, Oregon.**

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Precision MEASUREMENTS

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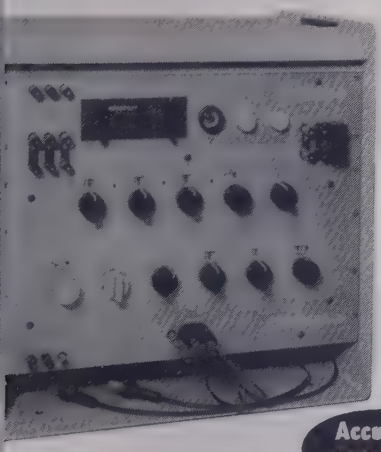
MODEL 700-A CAPACITANCE MEASURING SYSTEM



Both two- and three-terminal capacitors in the range from 0 to 1.2 microfarads can be measured. The resolution of the lowest range is 100 micro-picofarads (10^{-4} pf) per dial division. The resolution of the deviation dials is 0.001% (10 ppm) at all capacitance settings.

Deviation dials and complete bridge shielding provide for extremely accurate comparison of capacitors. For example, one picofarad standards can be compared to better than ten micro-picofarads (10^{-5} pf).

The bridge uses a ratio transformer circuit and a specially-designed, hermetically-sealed air capacitor having a very low temperature coefficient of capacitance and an exceptional stability. Accuracy of the measured capacitance is referred to this one standard which can be periodically checked and adjusted to agree with an NBS certified standard. This assures a minimum of drift due to changes of altitude, room temperature, voltage and frequency.

High input voltage capability (up to 350 volts at 1 kc) greatly increases measurement sensitivity.

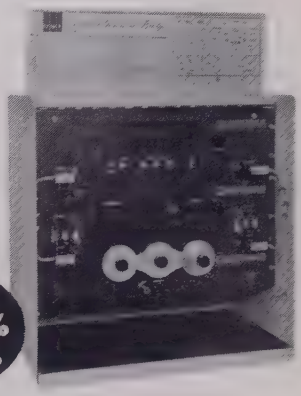
Accuracy ± 0.01%

700-A—Capacitance Measuring System/with cabinet $1725.00*
707-A—Capacitance Bridge 1350.00*
860-B—Generator-Detector 275.00*
SC-1000—Capacitance Standard (see separate description on next page.)

For Further Information Request Catalog Sheet C-28.

ODEL 291-A IMPEDANCE MEASURING SYSTEM

standing accuracy combined with simplicity of operation. Dc and ac impe-ce measurements covering seven decades of inductance, capacitance, resistance conductance, and three decades of D and Q. Five place readings. Resistance conductance accuracy to 0.05%. Inductance and capacitance accuracy to 0.1%. nplete with line operated ac and dc generator-detector units designed specific-as companion units for the bridge. Mounted in an attractive case with operat-instructions in the cover and an insulating platform for supporting compo-ts under test.

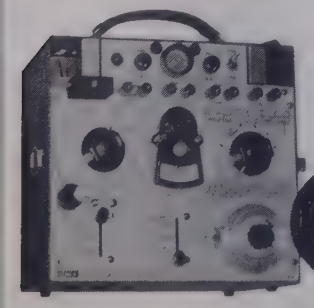


I-A—Impedance Measuring System (With Accessories)	$1,095.00*
D-A—Universal Impedance Bridge (Less Accessories)	495.00*
D—DC Generator-Detector	280.00*
D—AC Generator-Detector	250.00*

Accuracy R&G ± 0.05% L&C ± 0.1%

For Further Information Request Catalog Sheet C-13.

MODEL 250 PORTABLE IMPEDANCE BRIDGE



A self-contained, line-operated portable unit for making accurate measurement of impedance elements at dc and audio frequencies. Accuracy ratings of ±0.1% for resistance, ±0.2% for capacitance, and ±0.3% for inductance. D and Q measurements for capacitors and inductors. Price: $495.00*

Accuracy R ± 0.1% C ± 0.2% L ± 0.3%

MODEL 250-C1—The battery-powered version of the bridge, complete, less headphones. Price: $340.00*

MODEL 855-A1—A line-operated generator and detector for Model 250-C1. The combination is essentially equivalent to the Model 250-DA but has greater versatility for specialized measurements. Price: $170.00*

For Further Information Request Catalog Sheet C-16.

MODEL 270 CAPACITANCE BRIDGE

urate measurements of capacitance and dissipation factor at audio frequencies. Simple bration adjustment against reference standards. Accuracy ±0.1%; resolution 0.01%. ee-terminal connections; no zero capacitance correction. Seven capacitance ranges; e dissipation factor ranges.

Accuracy ± 0.1%

DEL 270—0 to 120 μf; 0.01 μμf resolution on lowest range. Price: $575.00*

DEL 270-H—Capacitance and dissipation factor ranges raised by a factor of ten; recommended at lower frequencies. Price: $650.00*

DEL 270-L—Capacitance ranges lowered by a factor of ten; low range resolution 0.001 μμf. Price: $650.00*

Further Information Request Catalog Sheet C-15.

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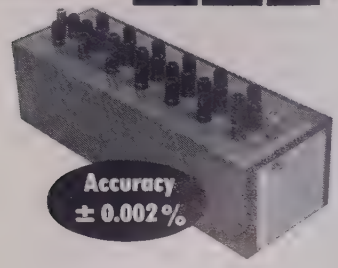
esi **Standards** AND



MODEL SR-1010 RESISTANCE TRANSFER STANDARD

Twelve equal resistors in a box, for transferring resistance measurements from a standa of one value to a resistance at a different value. Each resistor within ±0.005% of nomir value; short term stability suitable for comparisons of one part to a million. Designed f standardizing two-terminal and four-terminal resistance bridges, voltage dividers a ratio sets. Special junction design allows four-terminal series and parallel measureme without junction errors. Standard values: 1, 10, 100, 1K, 10K, 100K ohms (per resisto

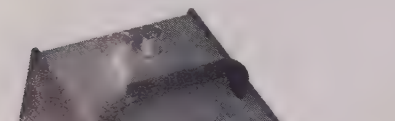
Price: $250.00* ea

For Further Information Request Catalog Sheet C-30.

MODEL SR-1 STANDARD RESISTOR

A small rugged laboratory standard resistor of high accuracy and stability, with low reactance and low temperature coefficient. They are supplied with an initial reading accurate to ±0.002% and have a long term stability guaranteed to ±0.005%. Two, three and four-terminal measurements are possible. Standard values: 1, 10, 100, 1,000, 10K and 100K ohms. Price: $15.00* each

For Further Information Request Catalog Sheet C-29.



MODEL SC-1000 CAPACITANCE STANDARD

The Model SC-1000 Capacitance Standard is a stable, precise, one nanofar (0.001μf) capacitor with a guaranteed three-terminal accuracy of 50 pp (0.005%). These capacitors provide a stable transfer unit of a convenient val for calibrating bridges or other capacitors.

Stability is assured by strong mechanical construction of the air-spaced capa itor plates. The choice of plate and spacer materials insures a temperature coe cient of capacitance less than 5 ppm per degree centigrade. Hermetic seali keeps the capacitance constant even though the dielectric constant of air chang with altitude almost 0.01% between sea level and 5,000 feet. Price, $250.00, f.o Portland, Oregon.

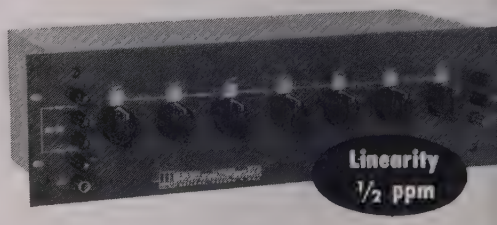
For Further Information Request Catalog Sheet C-35.

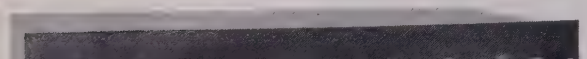
MODEL DT-72A DEKATRAN DECADE TRANSFORMER

A laboratory standard transformer-type ac decade voltage divider providing certified linearity starting at ½ ppm at larger dial settings and improving to better than 1/100 ppm at small settings. All units certified at the factory as a primary ratio standard in terms of an ESI standard traceable to the National Bureau of Standards.

Price: With ESI guarantee of specified linearity.....$695.00*
With ESI guarantee and certificate containing calibration readings with linearity accuracy of ½ ppm or better.....$795.00*

For further Information Request Catalog Sheet C-25.





MODEL RV-722
KELVIN VARLEY VOLTAGE DIVIDER

A precision resistive DC voltage divider providing 1 pp terminal linearity at full setting, and seven dial readout wi 0.1 ppm resolution. One year stability of 1 ppm is assured full setting. Output at zero setting is less than 0.004 ppm input. A calibration certificate is included containing init calibration readings accurate to 0.5 ppm linearity at the time final inspection. Price: $950.0

For Further Information Request Catalog Sheet C-14.

***All prices f.o.b. Portland, Oregon.**

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Decade Units

esi

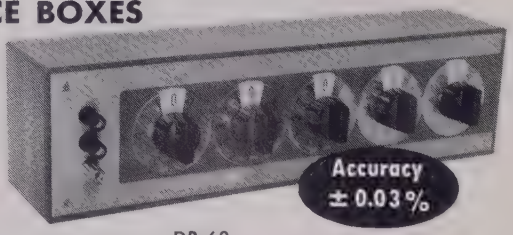
DEKASTAT® and DEKABOX® DECADE RESISTORS

Adjustable resistance standards of high accuracy containing one or more decades of precision fixed resistors. Some models include an interpolating rheostat. Accuracies to 0.005% initial, 0.02% long term. Temperature coefficient less than ± 5 ppm per degree Centigrade. Model DS Dekastat for panel mounting. Model DB Dekabox for bench use, Model RS Dekastat for rack mounting.

Prices: from $63.00 to $550.00*

For Further Information Request Catalog Sheet C-18.

DEKABOX®
IN-LINE DECADE RESISTANCE BOXES



ts may be obtained with four, five, and six decades with resolutions n 10 milliohms per step.

vidual resistors of 100 ohms and above have a temperature coeffi- t of 10 ppm/°C. and resistors below 100 ohms 20 ppm/°C. Accuracy djusment of decades is ± (0.03% + 1 milliohm/decade.) Total resistance of each box is 10 milliohms.

units are offered with total resistance values from 111.1 ohms to 1110 megohms.

Steps	DB-42 4 dials	DB-52 5 dials	DB-62 6 dials
0.01 Ω	111.1 Ω $125.00	1.11110 K $150.00	11.11110 K ...$175.00
0.1 Ω	1.1110 K $100.00	11.1110 K $125.00	111.1110 K ...$150.00
1 Ω	11.110 K 100.00	111.110 K 125.00	1.111110 meg . 160.00
10 Ω	111.100 K 100.00	1.11110 meg . 135.00	11.11110 meg . 195.00
100 Ω	1.111000 meg . 110.00	11.1110 meg .. 170.00	.....
1 K	11.11000 meg . 145.00	.....	.....

above prices f.o.b. Portland, Oregon

DEKAPACITOR® and DEKABOX® DECADE CAPACITORS

Adjustable, low loss decade units. Hermetically sealed polystyrene capacitors except below 1000 picofarads where high quality ceramic or mica capacitors are used. Accuracy 1%. Model DK-30 Dekapacitor for panel mounting. Model DC-40 Dekabox for bench use.

DK-30: 1μf–3 decades, for panel mounting. Price: $200.00*

DC-40: 1μf–4 decades, bench mount. Price: $240.00*

For Further Information Request Catalog Sheet C-18.

KAPOT® DECADE VOLTAGE DIVIDERS

Dekapot contains one or more resistive Kelvin-Varley decades and an rpolating potentiometer to provide high resolution and accurate volt- divisions. They are designed for panel mounting and utilize the exclu- ESI Dekadial concentric dials for direct in-line readout. Linearity from 1% to ±0.005%. Price: from $69.00 to $175.00*

DEL DP-451—A militarized version of the ESI Model DP-211. Certified eet the environmental test requirements of MIL-T-945A. The electrical ifications are identical to that of the DP-211. Standard values: 1K, 10K, 100K. Price: from $145.00 to $160.00*

Further Information Request Catalog Sheet C-23.

***All prices f.o.b. Portland, Oregon. Quantity discounts available.**

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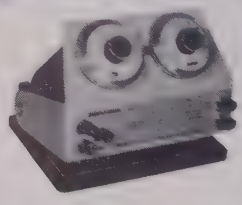
esi Dividers AND Networks

DEKAVIDER® DECADE VOLTAGE DIVIDER



Linearity ± 0.001 %

Resistive voltage dividers using the Kelvin-Varley circuit.

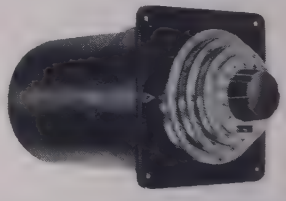
In-line control knobs on the rack mounted divider and the exclu sive ESI Deka-dial® coaxial dial of the bench mounted unit simpl fy dial settings and permit easy in-line readings. For use from d through audio frequencies.

RV-622A: precision resistors closely matched for maximum accu acy. Linearity 10 ppm, resolution 0.0001%. 10K Price: $450.00
100K Price: $500.00

DV-411: linearity 50 ppm, resolution 0.0003%. Price: $145.00

For Further Information Request Catalog Sheet C-23.

DEKATRAN DECADE TRANSFORMERS



...e transformers providing exceptional accuracy over a wide range of ...ronmental conditions.

...ODEL DT-45: three decades plus an interpolating potentiometer give accurate ...ve-place rea...ings of voltage ratio (linearity and resolution to 10 ppm).

...DEL DT-35: two decades plus an interpolating potentiometer give accurate ...-place readings (linearity and resolution to 100 ppm). All units designed for panel mounting. Price: DT-35, $160.00*; DT-45, $265.00*

For Further Information Request Catalog Sheet C-22 (DT-45); C-24 (DT-35).

Linearity ± 0.001 %

Accuracy ± 0.005 %

MODEL SV-194B VOLTAGE CALIBRATOR

A precision divider for calibrating potentiometric dc voltmeters. Alte nate techniques can be used for checking the accuracy of other types o voltmeters, power supplies and standard cells. Inputs of 1000 and 50 volts; outputs 1000, 500, 100, 50, 10, 5, 1.0, 0.5, 0.1, 0.05 and 0 volts. A calibration certificate is supplied, specifying calibration data accurac to ±0.005%. Price: $250.00

For Further Information Request Catalog Sheet C-26.

CUSTOM RESISTOR NETWORKS

High precision custom resistor networks are available to meet specific requirements. The resistors used are wound with wire which has a temperature coefficient less than ± 2 ppm per degree Centigrade, and are adjusted to extremely close tolerance after being put through a special aging process. The ruggedness and stability of ESI resistors makes them suitable for networks for field use, under difficult environmental test conditions. In laboratory applications, accuracies similar to those of ESI standard resistors can be supplied. In order to assure high reliability and accuracy, ESI networks are sold only mounted in suitable enclosures. ESI custom networks represent the solution to problems in temperature coefficient matching and special packaging.

Individual quotations will be made upon request.

*All prices f.o.b. Portland, Oregon.

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Computers AND Services

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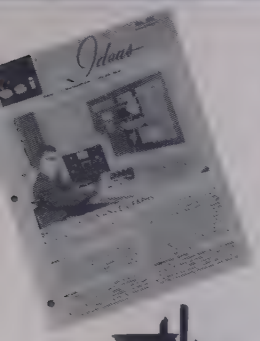

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ESI publishes a quarterly release called "Design Ideas." Its purpose is to inform our customers of advanced techniques and applications in the field of precision measurements. It also indicates ESI's progress in applying these techniques to development of "state of the art" equipment and procedures. Issues published covered such subjects as voltage divider calibration, precision resistance measurements and bridge performance graphs. The publications are mailed without charge upon request.

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Model 10 ESIAC ALGEBRAIC COMPUTER calculates solutions for the cteristic equations of circuits and control systems. The results are presented t-locus plots and Bode phase and gain diagrams. The root locus technique d to find closed loop response from open loop data for feedback controlled ns and it is also used for factoring polynomials. Bode plots present frequency nse in terms of gain and phase shift.

pid pole-zero programming allows the ESIAC user to study quickly the effect nges in system parameters or components. For example, the poles and zeros ompensating network can be added to correct an unstable system. The results e analyzed by a new root-locus plot in a matter of minutes. The ESIAC des a "feel" of the system that no other computer can equal.

Solves intricate system design problems in minutes instead of hours, hours instead of days. Write on your company letterhead for new 30-page brochure on theory, operation, advantages and typical, problem-solving appliactions of the ESIAC algebraic computer in dynamic systems design.

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(SEE INSIDE BACK PAGE)

Electro Scientific Industries

7524 S. W. MACADAM AVENUE • PORTLAND 19, OREGON

MAY 1962

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Instruction Manual

Electro Scientific Industries
7524 S. W. MACADAM AVE. • PORTLAND 19, OREGON

BRIDGES
AND
ACCESSORIES

JULY 1962

Model 860 A

AC GENERATOR-DETECTOR

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INSTRUCTION MANUAL

for

MODEL 860A AC GENERATOR AND DETECTOR

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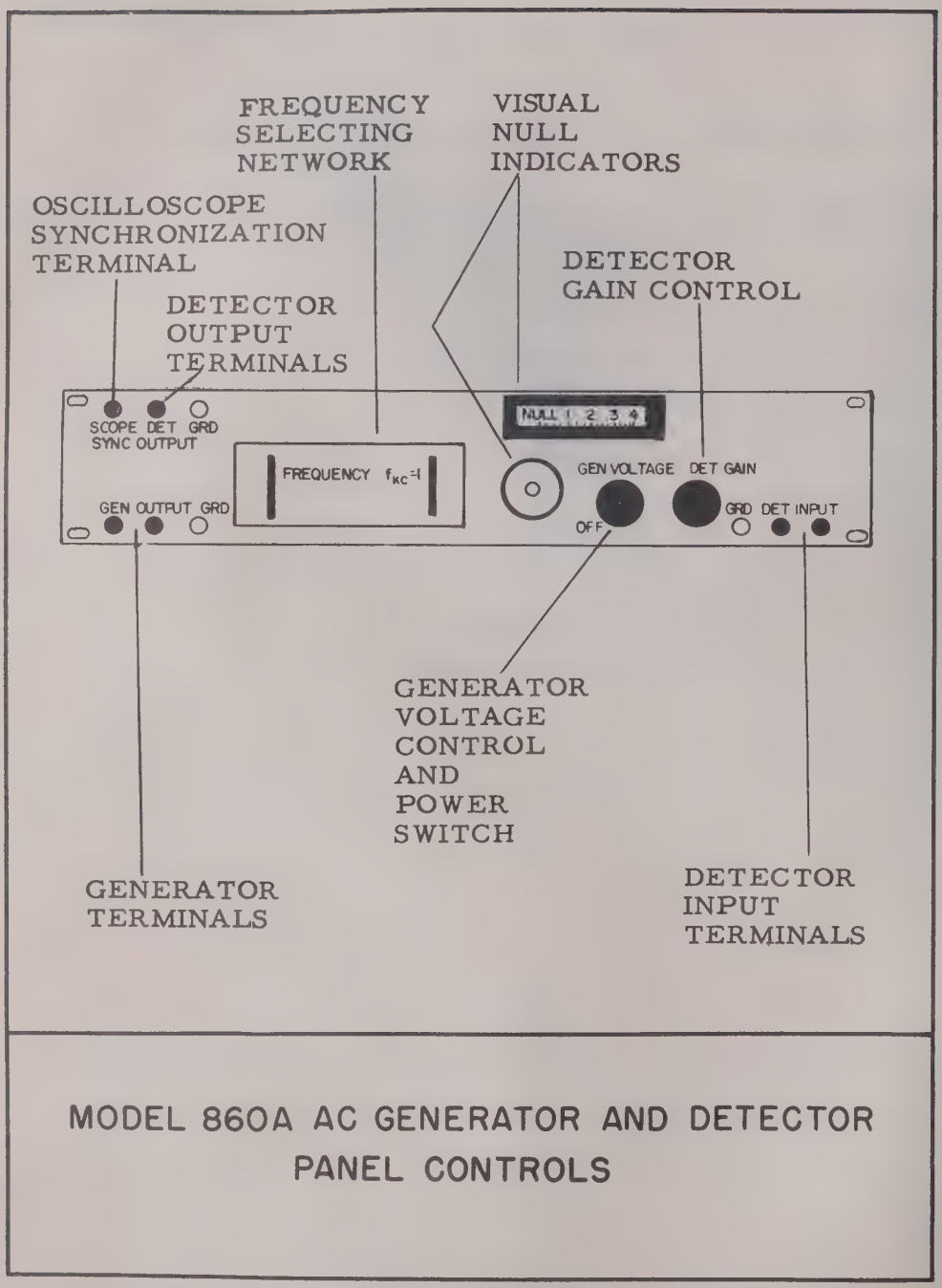
        - 1.1.2 Frequency Selecting Network
        - 1.1.3 Generator Terminals
    - 1.2 Detector
        - 1.2.1 Detector Gain Control
        - 1.2.2 Visual Null Indicators
        - 1.2.3 Detector Input Terminals
        - 1.2.4 Detector Output Terminals
2. Using the 860A
3. Circuit Diagram



MODEL 860A AC GENERATOR AND DETECTOR PANEL CONTROLS

1. CONTROLS

1.1 GENERATOR

1.1.1 Generator Voltage Control: The left hand knob controls the output voltage of the generator and operates the external power switch.

1.1.2 Frequency Selecting Network: The plug-in unit determines the operating frequency of both the generator and detector.

1.1.3 Generator Terminals: The lower left hand terminals are for connecting the generator to the bridge circuit. Both generator terminals are insulated from, and have low capacitance to, ground. A ground terminal is provided for shield connections.

1.2 DETECTOR

1.2.1 Detector Gain Control: The right hand knob varies the sensitivity of the lower half of the eye tube and the meter null indicator.

1.2.2 Visual Null Indicator: The dual electron ray null indicator provides an extremely broad range of sensitivity. The upper eye responds to large signals and lower eye and meter responds to very weak signals. A null is indicated by the maximum opening of both eyes and null reading on the meter.

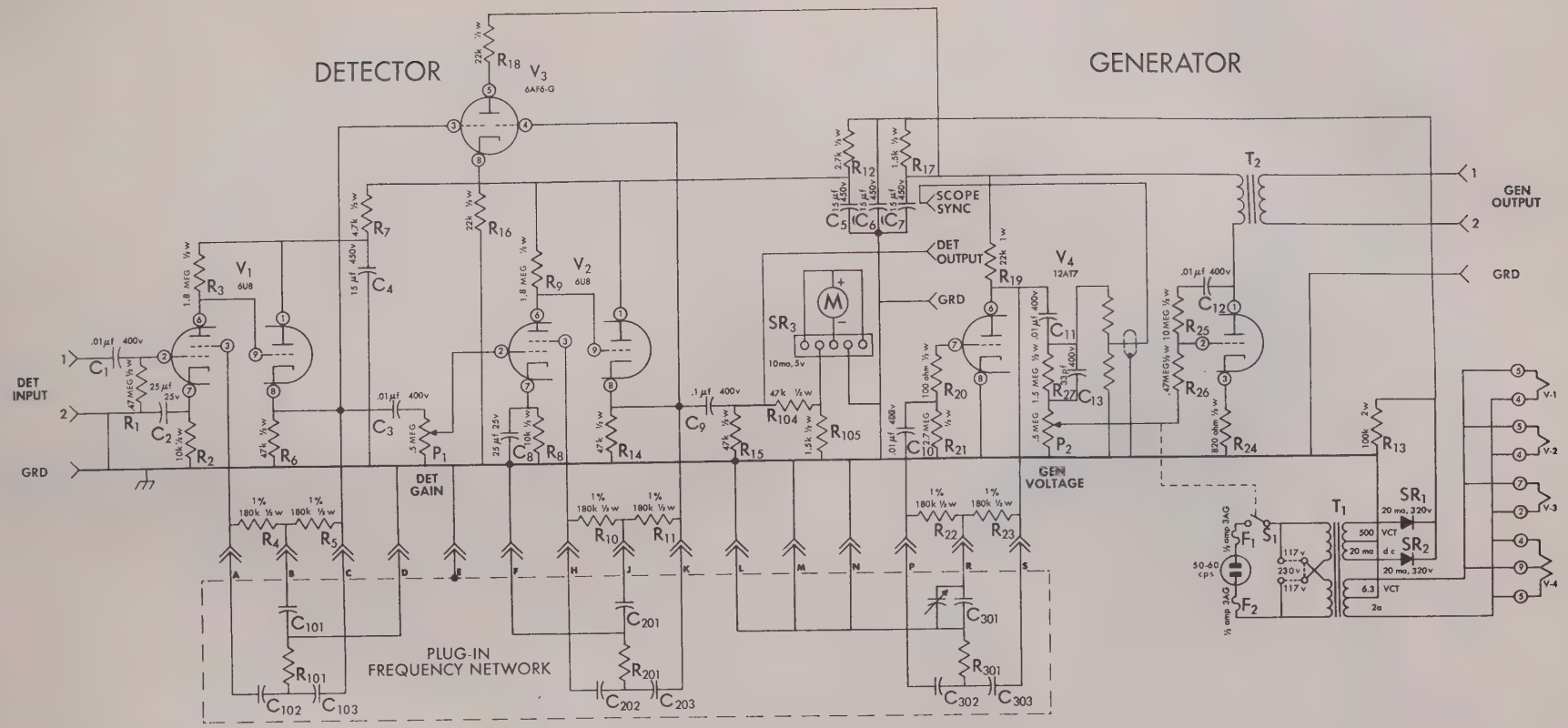
1.2.3 Detector Input Terminals: The lower right hand terminals are used for connecting the bridge circuit to the detector. The left hand terminal of this pair is internally grounded at the first stage of the amplifier. To minimize ground loop errors, the bridge circuit should be grounded only through this terminal. The terminal marked GRD is connected directly to the panel, and is provided for shield connections.

1.2.4 Detector Output Terminals: The upper left hand terminals are for connecting an oscilloscope or other indicator to the output of the detector amplifier. They are in parallel with the lower eye and meter null indicators.

1.2.5 Oscilloscope Synchronization Terminal: Between the upper left hand terminal and GRD a synchronizing signal for an oscilloscope is available. The null signal can be presented as a Lissajous elipse or a synchronized sine wave on an external oscilloscope.

2. USING THE 860A AC GENERATOR AND DETECTOR

CONNECT GENERATOR OUTPUT AND DETECTOR INPUT TO BRIDGE	Set generator voltage control to off for safety.
SET GENERATOR VOLTAGE CONTROL SO THAT THE REFERENCE MARK IS POINTED UP	This turns on the power supply, and provides sufficient generator voltage for most measurements.
SET DETECTOR GAIN CONTROL SO THAT THE REFERENCE MARK IS POINTED UP	This provides sufficient detector sensitivity for most measurements.
BALANCE BRIDGE	The null is indicated by maximum opening of both eyes and a NULL reading on the meter. The pattern edges of the eye will be sharp at null but will remain fuzzy for a minimum which is not a true null.
IF ADDITIONAL SENSITIVITY IS NEEDED, INCREASE THE GENERATOR VOLTAGE AND/OR DETECTOR GAIN	Maximum sensitivity may be needed for bridge measurements of very high or very low impedances.



Model 860A AC GENERATOR-DETECTOR CIRCUIT DIAGRAM

PARTS LIST

ESI MODEL 860A

REFERENCE DESIGNATION	PART NO.	DESCRIPTION
		CAPACITORS
C_{13}		Capacitor, 33pf, 5%, 400v, Arco
C_1, C_3, C_{10}, C_{11}, C_{12}, C_{14}		Capacitor, 0.01μf, ± 20%, 400v, Sprague
C_9	1430	Capacitor, 0.1μf, 200v, Vitamin Q 19P1049252 Sprague
C_2, C_8		Capacitor, 25μf, 25v, Sprague
C_4, C_5, C_6, C_7	5273	Capacitor, 15-15-15-15μf, 450v, Sprague 448778
C_{101}, C_{201}		*Capacitor, 2500pf, 1%, 500v
C_{102}, C_{103}, C_{202}, C_{203}, C_{302}, C_{303}		*Capacitor, 1000pf, 1%, 500v (OSC) Arco
C_{300}		*Capacitor, Trimmer, Arco 467
		CONNECTORS
P_1	2527	*Plug, Cannon, DP-2-15-33-1
J_1	2531	Receptacle, Cannon, DP-2-15-34-B
		DIODES
SR_1, SR_2	2535	Rectifier, Solenium Selectron 20Y2B
SR_3	1805	Bridge, Rectifier Conant Type B

REFERENCE DESIGNATION	PART NO.	DESCRIPTION
		RESISTORS
R_{20}		Resistor, 100 ohms, 10%, 1/2w AB
R_{24}		Resistor, 820 ohms, 10%, 1/2w AB
R_{17}		Resistor, 150 ohms, 10%, 1/2w AB
R_{12}		Resistor, 2700 ohms, 10%, 1/2w AB
R_{7}		Resistor, 4700 ohms, 10%, 1/2w AB
R_{2}, R_{8}		Resistor, 10,000 ohms, 10%, 1/2w AB
R_{16}, R_{18}		Resistor, 22,000 ohms, 10%, 1/2w AB
R_{19}		Resistor, 22,000 ohms, 10%, 1w AB
R_{6}, R_{14}, R_{15}		Resistor, 47,000 ohms, 10%, 1/2w AB
R_{13}		Resistor, 100k, 1%, 2w AB
R_{4}, R_{5}, R_{10}, R_{11}, R_{22}, R_{23}		Resistor, 180k, 1%, 1/2w Electron
R_{1}, R_{26}		Resistor, 470k, 10%, 1/2w AB
R_{27}		Resistor, 1.5 MEG, 10%, 1/2w AB
R_{3}, R_{9}		Resistor, 1.8 MEG, 10%, 1/2w AB
R_{21}		Resistor, 2.7 MEG, 10%, 1/2w AB
R_{25}		Resistor, 10 MEG, 10%, 1/2w AB
R_{101}, R_{102}		* Resistor, 58k, 1%, 1/2w DC Electra (AMF)
R_{103}		* Resistor, 51k, 1%, 1/2w DC (OSC)
R_{104}		Resistor 47k, 10%, 1/2w AB
R_{105}		Resistor 1500 ohms, 10%, 1/2w AB

REFERENCE DESIGNATION	PART NO.	DESCRIPTION
		TRANSFORMERS
T_1	A5116	Transformer, Power, Triad S8U3A
T_2	1253	Transformer, Interstage, Electro A-231
		ELECTRON TUBES
V_1 V_2	5275	Tube, 6U8, Miniature
V_3	5374	Tube, 6AF6G, Octal
V_4	5376	Tube, 12AT7, Miniature
		METER MOVEMENT
M_1	1119	Simpson, Model 1844C, Special scale

* Contained in the Hx. Plug in Frequency Network only.

RECOMMENDED SPARE PARTS LIST
ESI MODEL 860A AC GENERATOR DETECTOR

ITEM	PART NO.	DESCRIPTION	RS*
1.	1268	Knob	1
2.	1294	Cap, Binding Post Ins.	2
3.	1296	Cap, Binding Post Metal	1
4.	1393	Binding Post	2
5.	2755	Tube Shield, Eye	1
6.	1805	Rectifier Type B	1
7.	3140	Meter	1
8.	2675	Transformer	1
9.	3400	Network Assy 1 kc	1
10.	1277	Washer, Shoulder	2
11.	2525	Adapter	1
12.	3175	PC assy, Amplifier Osc	1
13.	3123	Dust Cover	1
14.	5274	Tube 6AF6G	2
15.	5275	Tube 6U8	3
16.	5276	Tube 12AT7	2
17.	1802	Fuse 1/2 amp	4

*Recommended for sparing to sustain operation for 18 months.

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